Chapter 4
Discharge and Flashover Behavior in Oil-Paper

ABSTRACT

Due to special operating conditions, the valve side bushing of the converter transformer connected to the converter valve is subject to complex voltage excitation, including DC voltage, AC/DC composite voltage, lightning impulse overvoltage, or composite voltage of operating overvoltage and DC. Under the action of this complicated electric field, the oil-paper insulation of the valve-side bushing of the converter transformer is prone to electric field distortion due to charge accumulation, which causes a surface discharge, which will seriously cause the edge breakdown. At the same time, since the temperature in the converter transformer rises due to a large amount of loss during the operation of the transformer, creeping discharge is more likely to occur under the electrothermal composite field. Hence, it is significant to carry out research on the surface discharge characteristics of the oil-paper insulation on the valve side of the converter transformer under the electrothermal composite field.

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INTRODUCTION

UHVDC transmission has the advantages of large capacity and low loss. Converter station equipment is the most critical part of HVDC technology, and its reliability is the key to ensure the safe and stable operation of the whole system. (Flourentzou, 2009; Piovan, 2010). Oil-paper insulation is one of the most commonly used insulating materials in converter transformers due to its excellent electrical and mechanical properties and good thermal stability. Due to the complex operating environment of the converter transformer, the oil-paper insulation in the side winding of the valve should bear not only DC voltage and AC voltage, but also various overvoltages (Chao, 2010; Wang, 2012; Sima, 2015). In actual operation, the overvoltage usually consists of the pulse voltage superimposed on the working DC voltage. In addition, the temperature rise in the converter transformer will also lead to the decline of the reliability of oil-paper insulation (Vasa, 2017).

Under the action of electric field for a long time, electric charge tends to accumulate on the dielectric surface, which will cause local electric field distortion and then cause surface flashover and insulation system failure (Leblanc, 2015; Jadidian, 2012). In addition, the surface charge behavior of the insulation system becomes more complicated under the superimposed voltage, and the surface flashover of the dielectric is more likely to occur under the superimposed pulse voltage of the DC voltage. It has been proved that the frequency, amplitude, number and polarity of the pulse voltage all affect the accumulation and dissipation of surface charges (Du, 2015a, 2015b). The dielectric breakdown characteristics of oil-paper insulation system depend on the polarity combination of pulse voltage and DC voltage (Okabe, 2015; Du, 2018).

In addition, temperature will speed up the process of the SPD, which affect the dielectric distributions of traps (Zhou, 2017; Du, 2017). The surface flashover of the dielectric is also closely related to temperature. It is found that the initial voltage of partial discharge decreases with the increase of temperature (Zhou, 2013). When polarity reversal voltage exists, the decrease of accumulated charge on the dielectric surface will cause the flashover voltage to rise (Du, 2016). However, there are few studies on the surface charge and flashover properties of oil-paper insulation under the action of electric and thermal fields. Therefore, this chapter aims to explore the flashover mechanism of oil-paper insulation, which is affected by superimposed voltage and temperature.